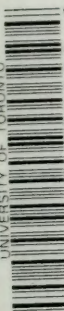


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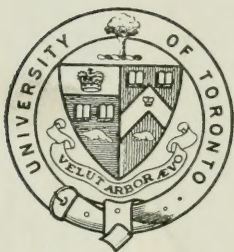


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THE DREDGING OF GOLD PLACERS

J. E. HODGSON

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THE DREDGING
OF
GOLD PLACERS

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THE DREDGING OF GOLD PLACERS

BY
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PREFACE

DURING the past two years the writer has contributed to English and American periodicals several articles, dealing with the phase of mining to which the following pages are devoted. Some interest appears to have been aroused among both mining men and the lay public by these articles, and the wish has often been expressed that they should be incorporated in one volume. This book is an attempt to meet that desire. The industry is a comparatively new one, and the views of dredging men in regard to many questions, both of construction and design, are still in a state of flux. This book is offered to the world, therefore, not by any means as a technical work, but in the sincere hope that it will help and interest company directors, property managers, prospectors, and those of the investing public who have acquired, or think of acquiring, a share interest in a gold-dredging concern.

I am indebted to two works, *Prospecting for Minerals*, by Mr. S. Herbert Cox, and *Gold Dredging and Mechanical Excavators*, by Captain Longridge, for some of the information which my book contains.

JOHN ERNEST HODGSON.

DUNKWA,
WEST AFRICA.

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THE DREDGING OF GOLD PLACERS

CHAPTER I

SOME NOTES ON THE HISTORY AND PROSPECTS OF ALLUVIAL GOLD-GETTING

THE records of gold-washing have been traced back to well nigh prehistoric periods, and the yield from the auriferous deposits of the ancient world must have been enormous. The goldfields of Siberia (lat. 50° to 55°) which are now again being opened up, but with modern machinery, supplied the people round the Euxine Sea with the gold which they used in their barterings with the Greeks, and it is a well authenticated fact that the Gothic tribe of the Massagetæ obtained their immense wealth from the same source.

History has familiarized us with the way in which Cræsus is said to have derived his wealth from the golden sands of the Pactolus. He must have completely worked

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them out, for there is no gold to be found in the sands of Asia Minor at the present time. The records of Ancient Rome tell us of the immense "glut of gold" which originated in the Alps, while Polybius mentions that gold mines were so rich about Aquileia that good "colours" were obtainable at a depth of only 2 ft., and that the workings were seldom taken down more than 15 ft. below the surface. The Phœnicians won gold from the bed of the Tagus in 1100 B.C., the contemporary Egyptian mines were spoken of by Diodorus Siculus as yielding "great riches," and the workings of Kordofan were mentioned by Herodotus. Nearly the whole of Africa has always yielded gold, though the amount recovered during the four centuries preceding 1875, about £107,000,000, did not more than equal the output of South Africa alone during any recent three years. It can safely be said that hardly a portion of the earth's surface is without traces of gold. India, Korea, Australia, Siberia, Africa, America and, in a lesser degree, Europe, either have been or are producers of the yellow metal.

Veins and leads that were abandoned by the ancients as unpayable, such as the mines

of Madras, are now being worked and found remunerative through the aid of modern applied science. Considering the ages that have elapsed, however, remarkably little progress has been made in the art of extracting alluvial gold. In underground work we have introduced Electricity and all the other developments of our scientific and mechanical knowledge, but in the working of alluvials there is practically no room for advancement, and one is tempted to believe that we have almost reached finality. We need, first, gold-bearing gravel, after which we look for the water with which to wash that gravel. Once these things are established, we need only grade and a convenient place into which to dump the *débris*. Water and grade, which cost nothing, do everything for us, as they did for the ancients, and the most we can do is to devise mechanical aids to nature. In this direction the dredge represents the last word. Practically all there is to know about actual free-gold saving is already known, and the aim of those connected with the industry is to adapt their contrivance to the varying and extraordinary conditions that obtain. To make the various dredge engines easily accessible and capable

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of being worked by the least possible number of men, to understand and allow for the various severe and peculiar strains that these engines and other parts are called upon to bear, and to cram the greatest table area and the largest number of disintegrating agencies into the smallest possible space are the legitimate aims of the dredge designer ; and it behoves all dredging men to make careful notes of and report upon all weak parts, possible improvements, and different conditions they meet with while actually operating their machine.

The fields for enterprise which exist to-day are too numerous for me to do anything more than specify. In the bed of almost every river that flows through or near mountains which contain auriferous reefs, gold is to be found. In many cases vast fields of gold-bearing gravel, deposited either by glacial or other action, cover the districts of which these rivers are for practical purposes the centre. The streams of North, South, East and West Africa give from fair to good prospects, those of West Africa being perhaps the richest and most easily workable. In South Africa the alluvial fields have, owing to the superior attractions offered by the

rich veins of the Rand, received but scant attention, but that good gold exists, well worth the attention of our industry, is proved by the recent discovery of rich alluvial in the Krugersdorp district of the Transvaal. Good reports also continue to come to hand as to the alluvial deposits in the Waterbury district of the Transvaal, and in one place it is said that an assay of 17 oz. to the ton has been obtained. Very many rich districts exist in East Africa, but they are rendered unworkable by the extremely bad climate and their consequent inaccessibility. The Gold Coast interior must be full of rich country. This is proved by the facts that the Ashanti Goldfields Corporation are discovering rich reefs in almost every part of their concession of 100 sq. miles, and that all the rivers carry good, and in some cases, very rich gold. In the Klondyke and Alaska there are good fields, the conditions of working which only require careful attention to make them payable. This goldfield was discovered originally by a working miner called George Carmack. He located gold in Bonanza Creek, which gave a prospect of about three dollars to the pan. Since then at least one prospect is recorded as having given fourteen dollars

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to the pan. In California the Oroville Dredging Company alone have no fewer than ten big dredgers at work and earning good dividends. Continuing down the great mountain backbone of the American continent, we come to the Republics of Colombia, Peru and Bolivia. The upper regions of the Amazon are full of workable propositions towards which, and into the streams which drain their bases, the Cordilleras of the Andes are continually draining vast quantities of gold through their foothill gorges. Only the notoriously unstable nature of the Latin Republican Governments prevents vast alluvial fields being opened up in the neighbourhood of the Andes. Further south still lies the Argentine, where there is plenty of promising territory, though it has not yet been found suitable for the dredging enterprise. In Tierra del Fuego and Patagonia good results are being obtained which will certainly be greatly improved upon when the country has been systematically prospected. As is only to be expected in a country containing such a vast number of reefs as both West and South Australia, rich patches of alluvial occur nearly everywhere, and the dredging industry there has become a big

one, while the gold of New Zealand has almost exclusively been won by dredging. In Burmah, conditions are somewhat against active work, though good gold undoubtedly exists, but in the neighbouring Malay States the Duff Development Company, with three dredges, has made a success of its undertaking. In Siam, Borneo, The Philippines, Japan (Hokkaido), Korea and Manchuria the natives recover large quantities of gold from the river alluvials by means of pans and cradles. Siberia is rapidly being prospected and developed by the Lena Goldfields and other companies, and all over the country, both in the Urals, the Centre and the East, the fact that the rather primitive "bockka," or perforated cylinder, of the Russians, is winning payable returns proves that here there must be a great field for enterprise. The Uda River, which flows into the Otkotsk Sea, is situated in a district which is well watered and wooded. As is the case generally in Siberia, it is reputed to be rich, but it has not been prospected properly. The snow lies from 7 ft. deep on the ground throughout the long winter, and in January the frost registers five degrees Réaumur. As in other parts of the world,

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labour is the bugbear. It is inefficient and the supply is variable.

Coming to Europe, we have the gold-bearing gravels and river beds of Northern Spain, which are not extensively worked because, in relation to the richness of the country, it is easier to work the vaster fields abroad, where the strict laws and high prices of land encountered in highly civilized countries do not obtain.

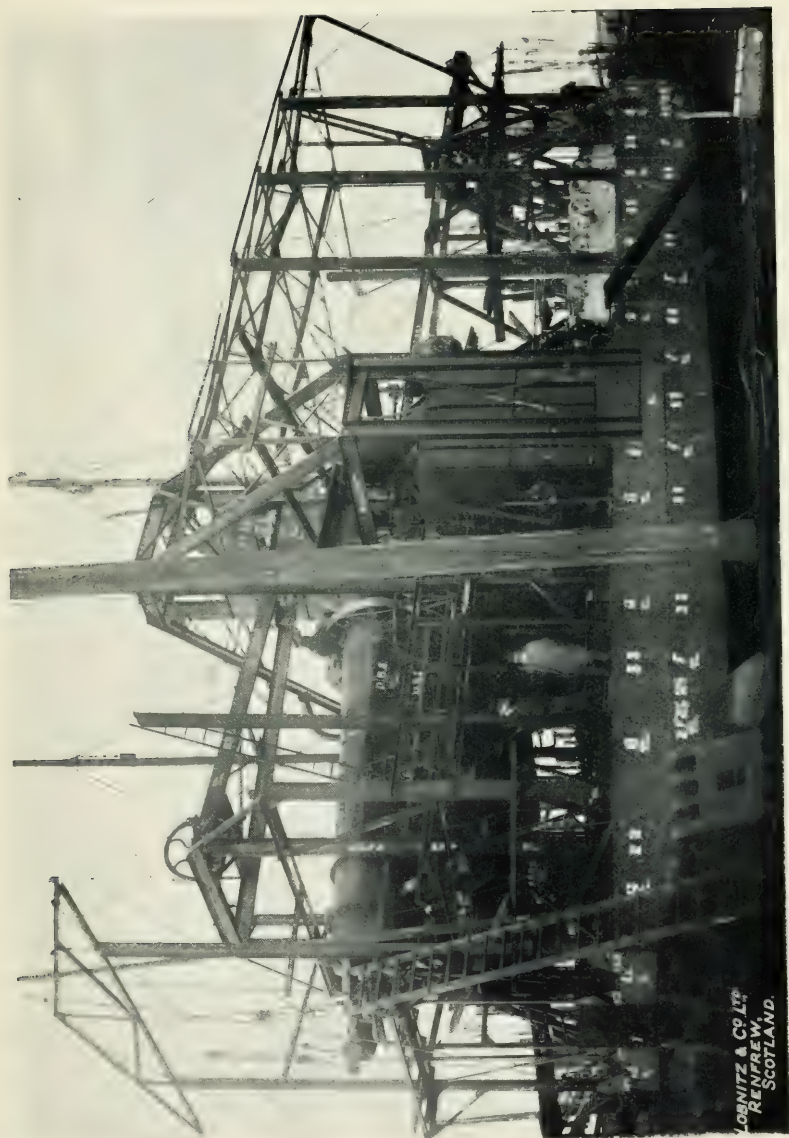
It is to be regretted that, huge and rich as the gold placers of Siberia are known to be, no really remunerative results have hitherto rewarded mining efforts in that country. During the last ten years many dredges have been placed in commission, a few of them largely native built, many of German manufacture, and some English—notably in the Ural and on the Zea and its tributaries; but, with a few exceptions, they have been unsuccessful. For the purposes of these remarks, the Ural district, where there are several quartz mines, may be disregarded, as it does not come within administrative Siberia, so that it can be said that 95 per cent. of the gold won is alluvial. The gold-bearing gravels are widely distributed. Each of the great rivers has along its drainage area several

“basins” which hold good placer gold, some of which “basins” undoubtedly rival in richness any other known fields in the world. From the placers of the Lena district, results approximating £5 to £6 per cubic yard have been won, and in the Yenesei valley, along the tributaries of the Amur and elsewhere, are to be found deposits which prospect even better than the phenomenal gravels of the Klondyke. The land and mine-owner in Siberia is, as a rule, a very lethargic person of no enterprise. The knowledge that dredging can be made to pay in New Zealand at 2½d. per cubic yard does nothing more than make him wonder why his costs are often over 6d. or even 1s. Of late, however, chiefly owing to the enterprise of one of the big German engineering firms, the dredge has made its appearance in Siberia. This is, of course, quite apart from the operations of the several big mining companies which during the last two years have been floated in London. The private dredges referred to were of cheap and flimsy construction, only calculated to be able to work without breakdown long enough for the original cost of them to be recovered. Dredges have also been built by St.

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Petersburg firms, bad as far as gold-saving appliances are concerned, though much stronger than the German machines in construction. It is gradually being recognized, however, that the dredges built in the English yards are by far the best in the world, both as regards their great strength and the care taken to fit them with the appliances most suitable for the particular class of work for which they are needed.

The question of careful prospecting, with which we have dealt at great length elsewhere, is of especial importance in Siberia. Many enterprises have been failures because work has been commenced in the wrong place. The heads of nearly all the rivers are full of rocks and boulders, while lower down, though the values are perhaps not as "flashy," there are practically no obstacles at all. The bedrock consists for the most part of decomposed rock to a depth of several feet, and is, of course, easy to work; but very often a stratum of soft greasy clay will overlie this. Great care should be taken to find out if this is so, because such clay will roll itself into balls and pick up gold in its passage down a sluice. It is further essential that the length of the "frozen" season



GOLD DREDGER FITTED WITH REVOLVING SCREEN

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should be ascertained as nearly as possible, for, although the area of frozen ground is much smaller than is generally supposed, the trouble occasioned by the climate is a great commercial one. The lying idle of an expensive dredge, its outfit and staff, for six or seven months of the year, is, on account of interest charges, deterioration, etc., of very serious moment. As is the case in connection with all systematic prospects of dredging propositions, the two secondary points of greater importance in Siberia are fuel and labour. Forest land abounds on the banks of all the important rivers, and wood costs about 6s. a cord delivered and stacked alongside dredge, or about the same as in West Africa. When wood can be obtained on anything like these terms, both electricity and coal are, of course, quite out of the question. Labour is, however, a much dearer commodity. It costs from 2s. to 6s. a day. Moreover, the Russian workmen, quick, intelligent and strong though they may be and are, are very susceptible to agitation, and where anything like large numbers of them are located together, trouble is almost sure to arise. In connection with labour it must also be remembered that

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the number of holidays expected by workmen has to be considered. In Siberia these holidays are frequent. In many parts of South America, where the people are Catholics and the number of feast-days is large, this item cuts seriously into the working costs of a property. In all such countries, therefore, a determined effort should be made not only to train efficiently a certain number of workmen, but so to attach them to their work and to the property as to reduce to a minimum the number of desertions and deflections through the occurrence of festivals.

There is one other problem which always faces those who intend dredging in Siberia, ignorance or neglect of which can also be laid to the charge of English managers and consulting engineers in other parts of the world. The contents of the placer fields are often to an extent limited, and if this fact has once been established it should be the aim of all concerned to amortize the initial cost of each dredge within the very shortest period of time after it commences work. Most of the big fields in Siberia are shallow as compared with those existing in New Zealand, and, as a result, a dredge eats up

its ground much more rapidly than in the latter country. In parts of West Africa there are narrow portions of the rivers the banks of which are not remunerative, are, in fact, quite undredgable, on account of the rapidly rising bedrock and the extraordinary amount of overburden. Again, in both Siberia and Africa certain big basins are inclined to be "patchy," and large portions of them have often to be pulled over because they are not worth working. A manager has not always either the time or the available information which will enable him to know exactly why and in what spots rich payable streaks occur, as they *do* occur, and frequently without any apparent cause. With regard to this mysterious reconcentration of mineral, it is possible that the explanation given elsewhere as to the travelling of frozen masses of gravel in the Klondyke and the British Columbian fields holds good in Siberia. The only other point that is of importance is the nature of the mining laws. In Siberia they are good, and conducive to even equable working; and it can fairly be said that both as regards the validity of titles and the regulations as to actual working they compare favourably

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with those in operation throughout the gold-bearing English colonies.

Enough has been said to illustrate the magnitude to which the gold-dredging industry may attain. There is no doubt that, in view of the facts that the only prospecting that can be absolutely relied upon is done by the dredge itself when in commission, and that hundreds of dredges are being erected all over the world, the industry during the next few years will assume very big proportions indeed.



CLOSE-CONNECTED SPEED DREDGER WITH BELT STACKER
AND WOOD PONTOON

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CHAPTER II

ALLUVIAL DEPOSITS

THE only minerals of any importance which are found in alluvial deposits are gold and other precious metals, tinstone, and those gems which by reason of their hardness and power of resisting chemical changes are preserved in their original state even after being scoured by water for long periods. It is now generally conceded that these alluvial mineral deposits owe their origin to reefs, though it is quite possible that nuggets such as are found among the gold dust far away from any possible reef source have been deposited by chemical and electrical agency. The probable great age of these alluvial deposits must not be lost sight of. Most theories as to old river-beds relied upon by alluvial prospectors of the old school are wrong. The gold was probably eroded from the parent reef at a very early period of the earth's history, and has since been carried by water in different directions over the earth's surface, so that the existence of alluvial gold will often afford no clue as to the reefs from which it originally came. The transportation of

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gold from the reef has gone on for countless ages, a time geologically short, but inconceivably long in comparison with the lives of men. The Andes, for instance, have been piling their *débris* about their own feet since first the Cordilleras began to rise out of the level plain. Dr. Evans, when working in the Bolivian foothills, observed that gold was more frequently met with in the ground just below the gorges, which proves that at such places the gold must have undergone a second and perhaps a third concentration, as nature undoubtedly in the process of time begins to cut down each successive elevation that rears itself above the normal level.¹

An instance of the fallacious theories which lead men astray was afforded by the Mangles River, a tributary of the Buller River, N.Z., in which some very rich alluvial occurred near the confluence. Near Macgregas the conglomerates of the local coal measures cease, and above this point little or no gold exists. The origin of the river-bed gold is, therefore, apparently quite clear, and many miners have spent much money and labour in unsuccessfully prospecting these

¹ A scientific analysis of the origin of many alluvial deposits will be found in *Prospecting for Minerals* by S. Herbert Cox, A.R.S.M. (C. Griffin & Co., Ltd.)

cretaceous coal measures for reefs. They appear to have quite ignored the fact that the gold was probably derived from the conglomerates and simply concentrated, and that the rocks are not such as would be likely to contain reefs. In British Columbia, also, a great deal of prospecting has been done for reefs in the vicinity of rich alluvial deposits, but with little success. In this case, however, the fact is that the gold has probably travelled a very considerable distance from its source, and the first part of its journey having been accomplished in icebound masses of earth it has not worn sufficiently to give an idea of the *distance* it has travelled.

The one distinct variant of alluvial deposits is the existence of beach deposits in certain parts of New Zealand and other places, where gold is found mixed with black sand about low-water mark. These deposits have hitherto been worked by means of a portable sluicing table which is wheeled down to the water's edge at low tide. The concentrative action of the sea on these beaches is such that after every big storm the gold in the black sand is renewed.

A discovery of great interest was made

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by Sir Martin Conway while investigating the tributaries of the Kaka, in Peru. The upper reaches of that river are within the torrential zone and contain fair gold. Four tributaries unite almost simultaneously just below this zone, and the river proceeds to flow through a narrow rock gorge in the bed of which practically no mineral can remain. It occurred to Sir Martin that below this gorge there would probably lie a large alluvial deposit which would have been reconcentrated and made richer by the action set up by the gorge. The place was accordingly prospected by a competent miner, and the most astonishingly rich prospects were obtained. The ground has been taken up, and is now being worked by both English and American mining companies. The same remarkable phenomenon exists in the Lower Inambari, Peru, district, where the richest alluvials have been discovered well outside and below the area which was originally investigated by the prospectors and thought to be the main auriferous region.

There are other points which render it necessary for prospectors of companies who are contemplating the erection of dredges to be exhaustive in their researches and

enquiries. Often enough big concessions have been taken up on the evidence of natives who are known to have recovered good gold and made a living by means of the pan. In Colombia, Peru, Korea, Tierra del Fuego and other places vast quantities of alluvial have been proved to exist which after trial have been found to be unworkable. In most cases the reason is that the rivers are torrential and full of boulders, and, therefore, totally unfit for dredging operations. In other cases, of course, they are on flats which are dredgable, but which do not come within the sphere of the hydraulic miner. In Ashanti the natives have doubtless recovered large quantities of gold in bygone times. Their method was to sink a shaft down as far as possible either to bedrock or water level, and to extract the coarser gold from the richer gravels. Their labour was forced, and, therefore, gratuitous, and their idea of "richness" was vague, so that their reputed results cannot be relied upon. The operations of dredges on the Offin River have proved that the mere existence of such holes does not indicate wealth, and it has been found that where the natives have gone to bedrock, as is frequently the case, the reason

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has been that it has been dry, which fact almost invariably means that it is above the river-bed from which the dredge could work, and is still rising, which means that it would be impossible to do even paddock work.

In the Republics of Colombia (Tolima) and Panama (Darien) there are huge tracts of country which appear to have been vigorously worked by the Spaniards, and which have been eagerly taken up by English and American syndicates, but which were originally worked by slave labour and have proved themselves to be unpayable under modern conditions.

The exact amount of overburden cannot be gauged over any big area, and many drill tests are necessary both to establish that fact and to prove the various depths at which bedrock is to be found. The latter information is very essential, as in dredging a sudden rise in the bedrock will often at once make it impossible for a dredge to work. It is quite common to find men who believe that bedrock lies as far from the surface at one spot on an alluvial field as it does at another, or that the thickness of the overburden is the same all over big stretches of country.

The factors that should be considered, therefore, are very various, and are as follows :—

- (1) The accessibility of the dredging ground.
- (2) Cost of transport.
- (3) Cost of local labour.
- (4) The existence of boulders, bars of rocks, and submerged trees, the first two of which will often preclude the possibility of successful dredging.
- (5) The proximity of firewood or other fuel.
- (6) The cost of clearing the adjacent ground.
- (7) The depth at which bedrock lies and its nature.
- (8) The depth of the overburden and
- (9) The thickness of the gold-bearing gravel.

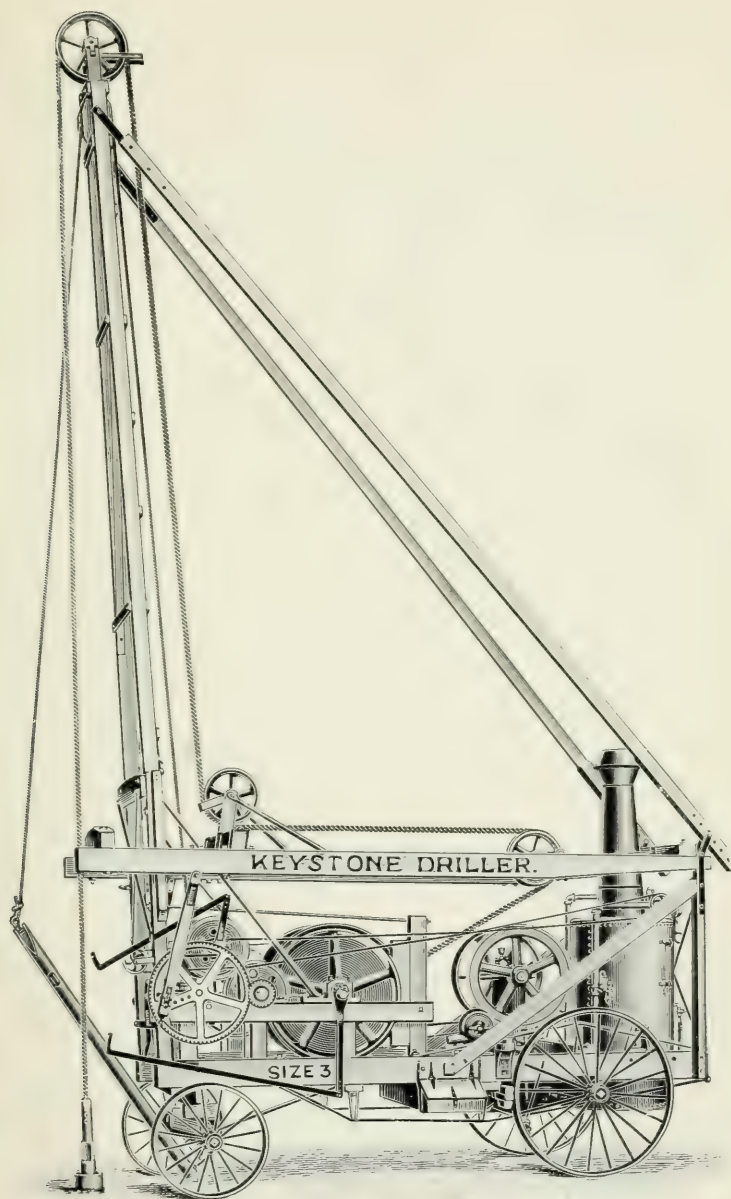
The only things that are necessary to establish these facts are intelligence and observation, a good knowledge of the country, a “keystone” or other drill, and a few shafts driven here and there for the purpose of corroborating the results of the drill tests.

CHAPTER III

PROSPECTING

THE great trouble in connection with most prospecting operations has always been that most soil contains gold in very variable quantities. The ordinary drill test must always be misleading in consequence of this, and an occasional shaft with a diameter of about 3 ft. is necessary for the purpose of checking the drilling machine. It is hard to speak definitely or comparatively of the performances of drills, because the nature and composition of the ground and the efficiency of the drilling crew influence the results so largely ; but it is safe to say that with the ordinary modern apparatus a gang of skilled hands should bore from five to six holes per day, the holes about 50 yards away from each other, to a depth of say 30 feet, if the soil is composed of sand, clay and gravel. As the depth increases the time expended, on account of the ticking out and replacing of tools, also increases.

These figures will not be approached in many countries, such as West Africa, where



KEYSTONE DRILL

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the native labourer is a stupid and ignorant person and very hard to teach. In many places, such as Surinam, the native is constantly looking for fresh work, and a gang cannot, therefore, be trained with that continuity which will alone ensure good and rapid work.

Innumerable drilling tests which have been followed by the dredge itself have proved to be of only problematic accuracy. The Ashanti Goldfields Aux., Ltd., dredged ground thus tested in 1907. The bore-holes had given from five to eleven and thirteen grains per cubic yard, but the results achieved by the dredge never gave more than two grains. In that case it must be admitted that sufficient care was not taken to feed clean water to the tables, and the paddock water became so dirty as to be able to carry off fine gold. Another dredge (New Zealand) is recorded as having recovered only 40 per cent. of the values indicated by the bore-holes.

The only case of which the writer ever heard in which a dredge verified the drill tests was in California, where a new modern machine obtained 92 per cent. Many of the Californian experts think that a drill test which sinks a 6" hole, gives, if worked by

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reliable operators, a test fully as accurate as a shaft. There is no doubt, however, that prospecting by shafts is the most satisfactory as with them it is possible to get an idea of the size and character of the gravel, and, of course, a much larger area of bedrock is exposed. It is held by some prospectors that the action of the boring plant is such that the flow of water down the rods is liable to carry away a certain amount of gold, but it is quite certain that in all cases where a sand-pump forms part of the equipment the gold brought up may have been largely obtained from the surrounding gravel. The procedure followed and spoken of by Mr. Newton Booth-Knox in a paper read by him in 1903 was as follows :—

“The drillings extracted from the drill hole by means of the sand-pump are discharged into a wooden trough, 12 ft. by 1 ft. by 1 ft., set on a slight grade. From the trough they are run into the riddle of a rocker, and rocked in the ordinary method adopted for washing gravel. Great care is taken to save all the extremely fine particles of gold, as upon this work depends the accuracy of the tests made. It is customary to clean up results of each pumping, and carefully to

note the number of countable colours obtained, and the character of the ground drilled through.

“For instance, a page of the driller’s note-book taken from actual practice is as follows:—

HOLE. NO. 14

| Pumping. | Colours. | Remarks. |
|-----------------|----------------------------|---|
| Surface—10 ft. | 1 speck | Red soil, clay, sand, and fine gravel. |
| 10 ft.—11 ft. | 22 fine colours | Gravel starts at 10 ft. |
| 11 ft.—12½ ft. | 52 colours and fine gold | Fine gravel. |
| 12½ ft.—13¾ ft. | 14 colours and fine gold | Coarse gravel. |
| 13¾ ft.—15½ ft. | 4 fine colours | Gravel softer. |
| 15½ ft.—16½ ft. | 4 fine colours | Gravel softer. |
| 16½ ft.—17½ ft. | 8 fine colours (1 fat one) | Gravel coarse. |
| 17½ ft.—18 ft. | 7 colours and fine gold | Gravel coarse. |
| 18 ft.—19½ ft. | 6 fine colours | Gravel coarse. |
| 19½ ft.—20½ ft. | 8 colours, some large | Gravel coarse. |
| 20½ ft.—23 ft. | 16 colours, some large | Gravel coarse. |
| 23 ft.—23½ ft. | 16 fine colours | Finer gravel. |
| 23½ ft.—24½ ft. | 21 colours and fine gold | Finer gravel. |
| 24½ ft.—25½ ft. | 8 colours, fine gold | Finer gravel. |
| 25½ ft.—26½ ft. | 13 colours, some large | Finer gravel. |
| 26½ ft.—28 ft. | 6 colours and fine gold | Finer gravel. |
| 28 ft.—28½ ft. | 5 colours, fine gold | Fine gravel. |
| 28½ ft.—29½ ft. | 8 very fine colours | Stopped in fine gravel |

Water level 21 ft.

“The term ‘fine gold’ is applied to such specks as are too small to be counted, but which play an important part in making up the total value of the hole. The gold from each clean-up is put in a small dish.

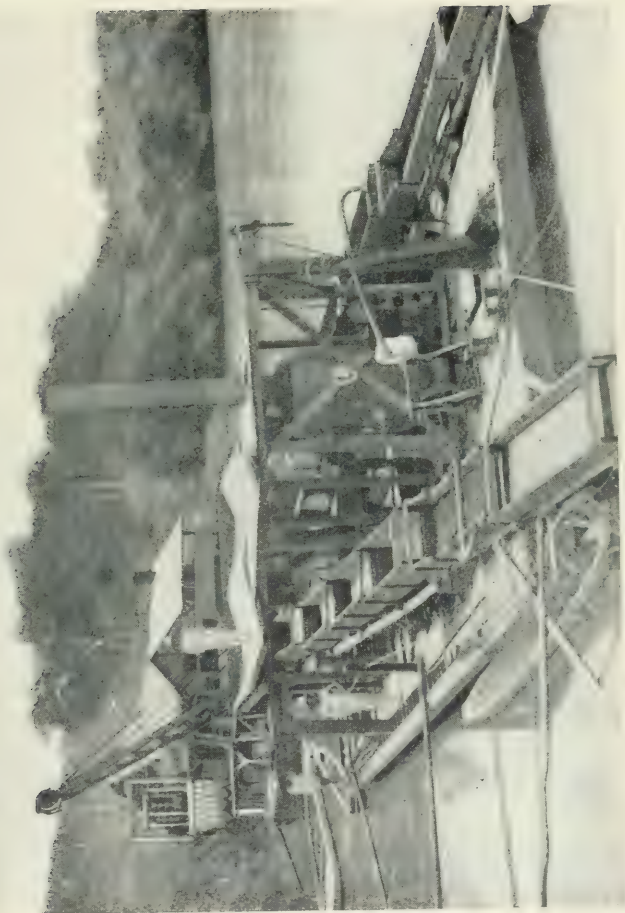
“This practice of cleaning up after each

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pumping (approximately after each foot drilled) instead of one final clean-up is all important in furnishing data for a cross-section map showing the occurrence of rich streaks, sandy or clay patches, depth of overburden, of false bedrock and of water level.

“After the last clean-up all the gold from the holes is collected by means of quicksilver forming an amalgam. This amalgam is dissolved in nitric acid and thoroughly washed in hot water. A few drops of alcohol added to the wash water will prevent spattering and loss of gold when the last drop of water is evaporated. The gold is annealed and carefully weighed. From this weighing the value of the ground at this particular spot is calculated and the results given in cents per cubic yard.”

The ideal boring apparatus, in order that it may be easily transported, should be very simple and divisible into parts of not more than 56 lbs. each. It should be capable of working, either by the use of light boring frames or through the well-hole of a dredge pontoon, or through the casing of any other type of vessel. It should be as capable of working in deep water or in marsh land as in firm exposed soil. No tool of any



DREDGER AND WASHER AS USED BY MR. WHITE, MANAGER OF THE NECHI
GOLD MINING COMPANY

From a photograph kindly supplied by Messrs. Priestman Bros.

description should ever be allowed to rest in the bore-hole during meal hours or at night time. Especially is this the case when working in sandy soil, as it may cause the tools to become stuck in the pipe, which circumstance generally makes it necessary to take everything out and consequently a lot of time is wasted. Care must be taken that the bore-hole is always kept quite vertical, otherwise at a certain depth the tool will refuse to drive properly. This is especially the case when going through ground containing boulders, which tend to deflect the drill head. To obviate this, the "Keystone drill" is fitted with a tool called a "jar" between the rock socket and the stem. It is like two links of a chain and when the bit is caught these two links come together with a shock, and jar the drill loose. As the value of the ground can only be determined by examining samples taken at regular distances, to be fixed by the nature of the stratum and the presence of the mineral, it is desirable that the tools bring up only such earth as is contained in the cylinder, and it is, therefore, essential for the tool to bore and the case to drive quite simultaneously and as nearly as possible at the

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same level. In calculating the values it is best to adopt the practice general in California, where the local engineers hold that the outside measurement of the case should be taken. They say that it is the *displacement* of the pipe and not the cubical contents that should be taken. In practice it is found that by taking the inside diameter of pipe the result is too high, and is never actually borne out by the results actually achieved by the dredges.

In case the reader should ever himself be actually prospecting with the drill, it should be mentioned that the operator must continually wash his hands as well as rinse down the rods with clean water. The effect of twisting or handling iron rods which are encrusted with sand or soil is to bring up very bad sores, and no prospector can do good work under these conditions.

The following is an extract from a paper read by F. W. Griffen, M.E., before the Californian Miners' Association in 1903, and confirms many of the conclusions which have been arrived at by the writer during the last few years :—

“Whether or not a piece of ground is suitable for dredging is determined by

physical conditions. To begin with, the deposit must be the result of a great flow of heavy gravel where the drainage area has been large and the 'feeders' good. The present creeks or streams which cut through a gravel deposit do not necessarily bear any relation to the original deposit. It must be practically flat lying, and the values must be disseminated over a wide area. You cannot dredge narrow, torrential portions of streams where large boulders abound. Where the bedrock is hard and the values are on that bedrock, the gold recovery of the dredge is materially reduced.

"A piece of ground which fulfils the above conditions will bear investigation. Great care must be taken in prospecting, not only in the work itself, but also in placing the holes, and particularly in drawing conclusions from the results obtained. Prospect work is generally done with a drilling machine which sinks a hole 6 inches in diameter. The test by drill is fully as accurate as the test by shaft so far as the values obtained from the gravel prospected are concerned, but careful expert judgment must be used to reach an approximately accurate conclusion from the result of either drill or shaft. The

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reason for this is that one hole to ten acres is considered close prospecting. Therefore, if ten holes are sunk on a one hundred acre tract, and if the total value of these ten holes is divided by ten, and this result is taken for the true average value of the property, it will surely be misleading. The more holes you sink the nearer you come to the true value of a property. My deduction from a great number of cases in actual practice is that a dredge will produce from 60 % to 70 % of the arithmetical average value shown by drill-holes when the holes are placed approximately one to each ten acres of ground. This does not mean that the dredge will not save more than 70 % of the values, but it does mean that the average value obtained from computing prospecting results as above set forth is erroneous by 30 %. If a property shows an average value of 20 cents per cubic yard, then a dredging property has been proved. This is true only when the drilling has been carefully done, and proper allowances have been made—further, the property must be located in an accessible place, where power is cheap. The two factors of transportation and power must not be overlooked, and where they are high,

the average value of the property must be proportionately high."

In prospecting, it must be remembered that wherever the current of a river has been checked by any means gold will probably be found, and it is essential carefully to study anything that has tended to cause a change in the direction of the river. It will be found that wherever a stream has eroded a bank on one side it has simultaneously deposited shingle on the other side, the probability always being that the shingle thus redeposited is poorer than that in midstream, to which point the bulk of the gold has, of course, a tendency to gravitate. Through having been washed of sands and practically reconcentrated, however, it will often be distinctly payable. Deposits of gold will often form on the quiescent shallow side of a stream and the main lead in midstream will not be of uniform richness.

As has been explained elsewhere, it is practically impossible to determine the former direction of the streams which have deposited the gold. Frequently the surface of the earth has been so changed in the meantime that it is hard to make definite deductions, and it is only after the river has

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actually been dredged that any data can be formulated. This brings us to a fact that cannot be too strongly insisted on. When all conditions are favourable very low grade gravel can be made to pay; in fact, even three to four grains per cubic yard gives a fair payable return, and very few bore-holes give a poorer prospect than that; but it is impossible to compute the wealth of a river-bed by any other means than by actually dredging it. Some idea may be gained by testing exposed portions of the river-bed at low water, by bore-holes, by erecting wing-dams and thus exposing portions of the wash, or by divers; but such means cannot be relied upon as being even nearly accurate, the consequence being that considerable doubt must always exist as to the amount of success which will attend the primary operations of a dredge. As an instance of the way in which false data have been gathered, false conclusions arrived at, and exaggerations quoted, we need go no farther than the Klondyke. As many as thirty-eight sluicing and dredging concerns started operations there in 1897, and many more attempts were made to float companies. The country was reported upon as being

suitable for all classes of hydraulic mining, whereas it was found in due time, and after millions had been squandered, that the gravels and nearly all the streams were for the greater part of the year both ice and snow-bound, that no roads for transport existed, and that many of the auriferous deposits were very patchy, and from almost every point of view quite impossible.

One of the best known and most reliable authorities on alluvial gold-getting in America recently gave me some interesting information from his own experiences. He says that check-holes do not necessarily serve as a good check upon the results obtained from holes previously drilled, though they are often useful as establishing the fact that the whole area of the ground is auriferous or otherwise. If one wants to check approximately the previous holes, the check-holes must, of course, be made very near those originally drilled. There is certainly a danger, however, of obtaining false results if the check-holes are placed only a few feet apart, as the ground may have been disturbed by boulders that have been pushed out of the way of the casing by the original drill. The first operator may have obtained much too

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flattering results by the running in of sand from the side of the casing, in which event the original hole might prove to be too high and the second hole too low in values to be anything like reliable. Whether a check-hole or a drill-hole is being put down, it can be safely assumed that the holes must be from five to ten feet distant from each other to be at all trustworthy.

CHAPTER IV

GOLD SAVING—DESIGN AND CONSTRUCTION OF DREDGES

A MODERN dredge can easily treat 18,000 tons of wash weekly. Therefore, every additional $\frac{1}{2}$ d. a ton extracted means over £1 a day extra profit. The question to which all dredging companies have to address themselves is whether this fact will justify the outlay of perhaps £3,000 in altering the details of construction in their dredges already in commission in accordance with the theories that are now being laid down, often by people without much definite knowledge of actual everyday working conditions. All such schemes as the treatment of concentrates by cyanide, amalgamation and Wilfley tables must still be experimental, for the simple reason that no one has as yet conducted many practical experiments or supplied any reliable data. The question naturally arises as to whether it is the work of the executive staff of the dredging companies to conduct costly and time-consuming experiments with their craft in commission, when every

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revolution of the engine means gold won, or that of the metallurgist at home first to supply them with some very definite data for their consideration. It should be recognized for obvious reasons that the man on the spot and the scientist at home must be in practical agreement before any large sums are spent in dredge alteration. In out of the way places it is always best to preserve the utmost simplicity of design and construction. It remains to be proved whether any of the alterations and additions to plant now advocated, beyond the screen and tables, jigging tables and puddler or stone extractor, can have the desired effect, *i.e.*, that of saving a bigger percentage of gold than is saved now.

Gold is often in a fine state of subdivision. Sometimes it is flaky and is called "float" gold (as is often the case in New Zealand). In spite of what is said to the contrary, sluices and undercurrents can catch this latter class. In Bolivia, where I met with and worked this class of gold, I failed to obtain anything like a decent prospect at all from the dump. In West Africa I found that the tiny particles often actually float, and that particles only a little heavier were

often lost either through the sand frequently choking the riffles and mats or the stream being of rather too great a velocity to allow of them sinking before reaching the end of the tables. Of course, I speak now principally of the chute dredges—so-called “old-fashioned.” Nothing can obviate the likelihood of uneven velocity of current in chutes. There is (1) the slight tipping of the dredge caused by the digging operation either in hard ground or against obstacles, (2) the swaying of the dredge owing to bad trimming or the pull on side lines, and (3) the blocking of the chute-head with clay, small logs or boulders, which hold up the flow. When these obstacles are released the flow is momentarily very swift.

The treatment of residuary sands is the point most discussed nowadays, The statistics published and supplied from time to time by consulting engineers and others as to the gold won from tailings is misleading, as such tailings have, by the mere act of passing over the chute, to say nothing of being redumped to a flowing river, been subjected to a reconcentration, the extent of which, of course, varies. It is unfair to say, if a test gives tailings a wealth of say

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2·50 grains per cubic yard, and the dredge originally won from the gravel 2·50 grains per cubic yard, that the dredge lost half of its values in treatment. A proportion of the sand and silt has, moreover, been already caught by the dredge tables. The assay tests put to black sands have not hitherto told us, except in isolated cases, that they form payable material, and, even if they appeared to do so, we have to consider whether the gold they contain is at all coated with oxides, and therefore impermeable to cyanide, and, in the case of shingle, whether it would pay to erect a mill such as would be necessary to crush the gravel before passing it to a Wilfley table. This once acknowledged, there are the further problems of extra staff required (and the present average dredge staff is worked hard enough), of continually drawing off and putting into lighters the concentrates so that the dredge has not to be greatly altered in construction to carry extra weight, the impossibility of doing such recovery work by contract and of gauging results on account of the dredge's gold that would be simultaneously drawn off, and the fact that in many countries no dredge is in one place sufficiently long to



BELT TAILINGS STACKER

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allow of the erection of a permanent plant on the bank. It must further be borne in mind that a major portion of the gold stated to have been lost by dredges is not contained in the concentrates and sands washed off the mats and lost in the process of washing up, but is shot over the end of the dredge. Practically the whole of the material treated by the dredge would, therefore, have to be re-treated in order to get the maximum recovery, which reduces the proposition to an absurdity.

The industry has been handicapped by the heterogeneous character of the dredges erected by the companies who have whole fleets at work. There are so many reputed improvements, both in dredge construction and gold-saving appliances, to be taken into account, and so many interests at work at home, that out of, say, five dredges in such a fleet there are often three distinct types of dredges. Consequently every part is to an extent bastard instead of being interchangeable, and, where there is no foundry within thousands of miles, and there are constant breakdowns, either the stock of spares must be inordinately large or long stoppages must occur. But this in passing. The main point

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is that material recovered and experimented upon must always be considered not only in the light of the conditions under which it was recovered, but in relation to the particular type of dredge which recovered it.

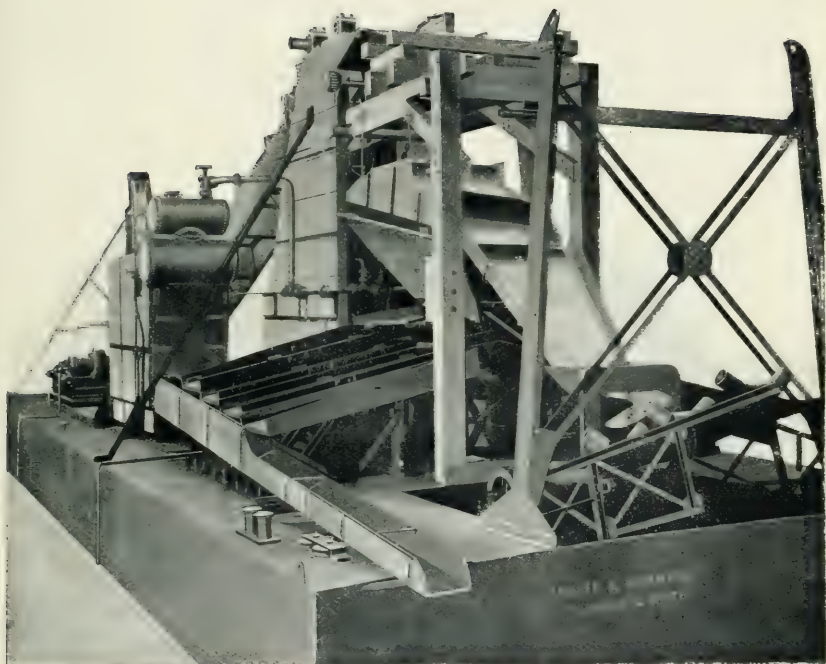
Some of the finest gold dust won to-day by dredges is obtained from the rivers of the West Coast of Africa. It is a surprising fact that the amount of visible gold to be obtained from the dredge tailings is often very small; and the proportion saved by the tables and even the chutes is very large. Both the grade of the tables and the velocity of the stream have of course, to be carefully considered and adjusted both in relation to the class of gravel being treated and the fineness of the gold contained in such gravel. The amount of gold recovered by dredges working over old dredged ground is not always reliable, and cannot be quoted as being anything like definite. The first dredge may have had any of the ordinary defects such as (1) too little or too much water, (2) an inadequate save-all which allowed gravel not tipped to the chute to drop back into the well-hole, (3) wrong chute gradient (4) large quantities of soft clay, which, on dropping into the chute, made the flow uneven, and

which revolved on their way aft, picking up particles of gold *en route*. Such lumps of clay would probably be disintegrated, and the gold dispersed before the second dredge got to work. The most important matter, however, is the difference in the class of winchmen working the first and second dredges. It is known to all dredgemasters that some winchmen, "new chums," such as the blacksmiths, fitters, etc., who are often spoken of as being suitable men to train to dredge for gold, are many months before they can grasp the idea of cleaning up the bottom. Very few of them really trouble to understand where and how the buckets tie when they reach the gravel. They can see nothing, so that unless a man has great intelligence it is a very hard matter for him to know whether to drop his dredge backwards or sideways on encountering an obstacle. If his common sense tells him to drop backwards, he is always afraid that he will fail to pick up his cut again in the right spot; and so on through little difficulties and puzzles too numerous to mention, but which all good dredgemasters will appreciate. Such winchmen will lose many ounces a week. Again, it is well known that good

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and experienced men will not, either through drink, or quarrels with their mates and their consequent attempts to leave the dredge "hid up" for their relief shift, or dissatisfaction with their employers or managers, or illness, give the ground the attention it deserves, nor will they give that attention to cleaning up the bottom and testing banks which is imperative if good results are to be obtained. One little instance will illustrate my meaning. There are some winchmen who will never observe that they are at times putting through too much silt and other fine stuff, and that the buckets must stop work for a minute or two while the pumps clear the chute or screen. They fail to see that if the tables become blocked with material there is a chance of quite an appreciable quantity of gold going overboard with it.

Nearly all the talk about "further and repeated concentrations" is unpractical. If the gradient and the flow of water is right, and if, in the case of a screen dredge, the inside of the screen is effectively and powerfully sprayed, the ordinary apparatus of a well-constructed and designed dredge is sufficient to save all the fine gold that is humanly



STEAM-DRIVEN OPEN-LINK DREDGER WITH STEEL PONTON, SHOWING
GOLD-SAVING TABLES AND SLUICE, LOOKING TOWARDS
BOW FROM STERN END

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savable. The modern apparatus which commends itself to me above all others is the jiggging apparatus designed and erected by Lobnitz & Co., of Renfrew, the well-known dredge designers and builders. The principal thing in its favour is, of course, the greater area of screening surface which is constantly at work as compared with that offered by a screen and tables.

As far as the streaming-down process is concerned, if care is taken by the man whose duty it is to clean up, no loss of visible gold can occur. In 1908, in consequence of observations I had made, I thought that one of my dredgemasters was losing gold. His tail chute, which in the first place he should have arranged to dump back to the tables instead of overboard, was too short and the slope of it too great, his baize and expanded metal were laid very carelessly, and he gave the box too much water. I at once placed a catch-box at the end of the tail chute and recovered 8 dwt. of gold. It was nuggety gold and had rolled. I altered the tail chute, etc., and then failed to find a trace of gold on the last two feet of it.

The proportion of gold which is really lost must always remain an open question.

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The majority of writers on the subject have never actually been engaged in the operation of dredging, and their statements are unreliable. Some say that 50 or 60 % is lost, while others say that only 25 % gets away. Mr. J. B. Jacquet, a well-known New Zealand dredgemaster, stated in 1899, when the screen and elevator type was a thing of the future, that it was quite a question whether, under ordinary circumstances, 10 % was lost in treatment, and many dredgemasters say that often as much as 97 % is recovered.

A method of gold-saving which the writer has tried with success is the use of wells with an U section, containing mercury, placed at intervals down the chute. The great drawbacks to any scheme of mercurial amalgamation is the ease with which gold can be stolen. Unless trapped or barred, the contents of the well can be extracted (when water is not flowing) by means of a teaspoon, and, where natives of the moral development of the Gold Coast negro are employed, care would have to be taken to prevent pilfering. The use of silvered plates in this connection cannot be advocated, because practically all the dredged gravel



GOLD DREDGER FITTED WITH PATENT PROPULSION SCREEN.

From a photograph kindly supplied by Messrs. Lobnitz & Co., Ltd., Renfrew, Scotland.

would be hurled upon them, and the plates would tend to scour quite clean in a very short time.

The following is an extract from a report submitted by the writer to his directors in 1907, and deals with the installation of cyanide and other gold-recovery plant.

“A far bulkier concentrate is wanted than is at present obtained, and it has been suggested that twenty tons must be caught per week instead of the present one-and-half or two tons. In order to carry such an increased bulk, the dredge would have to be practically rebuilt. An increase of eighteen tons in weight of concentrates is far too much for the present pontoons, to say nothing of the 200-300 cubic feet of extra space required for the installation of anything like an effective plant. . . . Wider tables have been suggested, but the wider a table is the easier it is to get an uneven flow over the riffler. With a wide sluice (over 5 ft.) any slight defect in trimming, for instance, would cause the contents of the sluice to flow continuously down one side of it, the other portion being meanwhile exposed and useless. The two questions which have undoubtedly given pause to the experts are (1) the guarding

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against possible large losses of cyanide through the dilution of working solutions, and (2) the most effective method, consistent with the small amount of available space on a dredge, of recovering the gold from the solution. The only instance that I can recall for the moment of cyaniding dredge concentrates is on the Obinimuri River, N.Z., where, with the advantage of a practically stationary dredge, a syndicate erected plant in 1903."

Mention has been made elsewhere of the great importance of the rate at which water flows down the chute in the case of sluice-box dredgers. The quantity of water passing, and its velocity must be uniform to secure a maximum recovery. It is, further, no economy to fill a chute full of dirt. Another point to remember is that water always flows faster in the centre of channels, and is always slightly higher in level there. Consequently the bulk of the gravel, etc., will flow down the middle of the chute. The width should be roughly two-and-a-quarter times the combined height of the two sides ; thus a chute with a side 1 ft. high would require to be 4 ft. 6 ins. wide. Grade, of course, increases velocity, and velocity increases the work

that can be done by water. These facts, although very elementary, must all be considered very carefully when one is designing a dredge chute and tables. A chute should never be allowed to sag in the centre. If it is raised a little in the centre instead of being concave, the result will be beneficial, as it will cause the gravel to distribute itself over the whole surface.

The physical quality of gold lost must not be determined by an examination of that caught in the riffles or on the tables, for the gold lost may have been taken overboard by reason of the fact that it differed in some way from that which proved itself capable of being caught. The character of the gold lost must be determined by repeated pannings from the buckets as they come up. An interesting point in this connection is that, if the gravel and boulders are large, the gold will generally have the same characteristics, while, if they are polished, the gold will be small and round or flakey, and much of it will be in the form of a fine dust.

In the course of this chapter I have, perhaps, dealt more fully with sluice-box dredges than screen dredges. It must not be

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forgotten that there are still a vast number of the former type in existence, doing, if anything, better work than the more modern dredges by reason of their infinitely greater simplicity.



THE PROPULSION SCREEN

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CHAPTER V

MERCURY, BLASTING, AND ODD NOTES

Mercury.—With impure mercury it is difficult to catch gold. If any oil, for instance, has dropped into the chute or on the tables from the bearings, it gets into contact with the gold particles, which refuse to amalgamate. Newly-bought mercury is often very impure, and all mercury should be periodically squeezed through a clean cloth. It also absorbs oxygen from the air, and the oxygen forms a filmy covering or “skin” over the metal, which, slight though it is, prevents its instant combination with gold. This skin can be removed by passing a cylindrical and quite dry glass tube, to which the “skin” will adhere, over the surface of the quicksilver. If very great purity is required, it is best, after distillation, to put it back into its iron bottle, adding to it nitric acid mixed with double its own volume of water. When the whole is heated to, say, 150° Fahrenheit, a certain amount of nitrate of mercury is formed, and this, together with the free acid present, dissolves the foreign

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metals, together with any oxide of mercury which has been formed by the contact with air during distillation. Leave the acid in the water for twenty-four hours, shaking it well from time to time, then heat the bottle gently to drive off the water. A thin crust of nitrate of mercury will cover the surface. This can be removed and the metallic mercury can be recovered from it. The mercury should then be well washed with clean water. Very few dredgemasters have any knowledge at all of mercury, and hundreds of ounces are lost annually through insufficient care being taken to see that it is clean. It must never be left in contact with the atmosphere, from which it gathers oxidization. If the only fault is this oxidization, pour it into a glass bottle and add a little concentrated sulphuric acid (SO_3). Shake the bottle till the mercury is broken up into globules, which will bring it into contact with the acid, and after two or three days pour off the acid and thoroughly wash the mercury.

* * * *

Blasting.—In almost all kinds of country there are rivers which have cut their way through rock ridges, and the beds of which



THIS PATENT CARTRIDGE PROVIDES, IN THE EVENT OF A MISSFIRE, FOR THE AUTOMATIC DESTRUCTION OF THE EXPLOSIVE (THE MAKERS' "CHEDDITE") CONTAINED THEREIN

hold either big boulders or rock outcrops, while in tropical and heavily wooded countries either the river-beds contain sunken logs and tree-trunks or big trees grow close to the water's edge and on dredgeable ground. The subject of blasting, therefore, must always call for some attention. Up to 1876 common blasting powder was almost universally used. After that year Judson powder was introduced, while combinations of black blasting powder and giant powder were also experimented with. Of late years the explosive most in use has been Nobel's dynamite.

* * * *

Gold.—The comparative purity of gold is expressed by the term “fineness” and this is estimated on the basis of 1,000 as a unit of measurement. Thus a nugget containing 78 % of gold, 18 % of silver and 4 % of other substances will be said to be 780 fine.

* * * *

The physical qualities of gold are such that, while it will remain almost wholly intact under chemical action, it is easily affected by abrasion, and if carried for considerable distances together with gravel it is ground rapidly to the finest powder.

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In nature, gold never occurs pure, being invariably accompanied by a little silver and other metals. Its colour varies according to the preponderance of copper or silver in this alloyed mineral.

* * * *

Gold has a tenacity sufficiently great to sustain, in a wire one-tenth of an inch in diameter, 500 lbs. weight without breaking. In hardness it is above lead and tin, but inferior to iron, copper, platina or silver. Its lustre does not equal that of steel, platina or silver, but it surpasses all other metals in this respect. It suffers no change by exposure to air or moisture, even when heated. When in fusion it has a brilliant green sheen on the surface. It is scarcely at all volatile, and may be kept in fusion in a furnace for a long while without losing weight. When it is melted by the heat of a lens, however, a plate of silver held over it at some inches distant becomes gilded by its vapour. It contracts more than any other metal in cooling and crystallises in octohedrons. One method of ascertaining the presence of alloys in gold is by trial of specific gravity, and it was in this manner that Archimedes detected the amount of silver in a crown

which was to have been made of pure gold for Hiero, King of Syracuse. This method, however, only gives an approximation, since certain alloys are more and others less dense than the mean density of the metals that compose them.

* * * *

The malleability and extreme divisibility of gold are the foundation of the art of "gold-beating." So great are these two properties in gold that natural philosophers are in the habit of quoting the facts as examples of the divisibility of matter. Boyle has observed that a grain of gold, reduced to leaves, will cover a surface of 50 square inches; that each of these square inches may be divided into 46,656 other little squares; and that, therefore, the entire amount of surface derived from one grain of gold is capable of being divided into 2,322,800 parts, each of which would be visible to the naked eye. It is estimated that an equestrian statue of the natural size might be gilded with a piece of gold of the value of 10s. The work of gilding the dome of the Hôtel des Invalides in Paris cost about £4,000. These facts were probably either overlooked or discounted when estimates were made

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a few years ago as to the amount of gold contained in the several sacred lakes of the Incas in South America. Documents emanating from the explorers of the fifteenth century, which I have myself perused in Paris, state that evidence existed that the Chiefs, for the purposes of their periodical sacrifices and religious rites, covered themselves with gold dust and bathed in the water. This has always conveyed the idea that fabulous riches are buried in the lakes in question; but I have myself recovered gold dust from the Jim River in Ashanti so fine that four dwt. of it would give a naked man the appearance of being covered with the precious metal.

* * * *

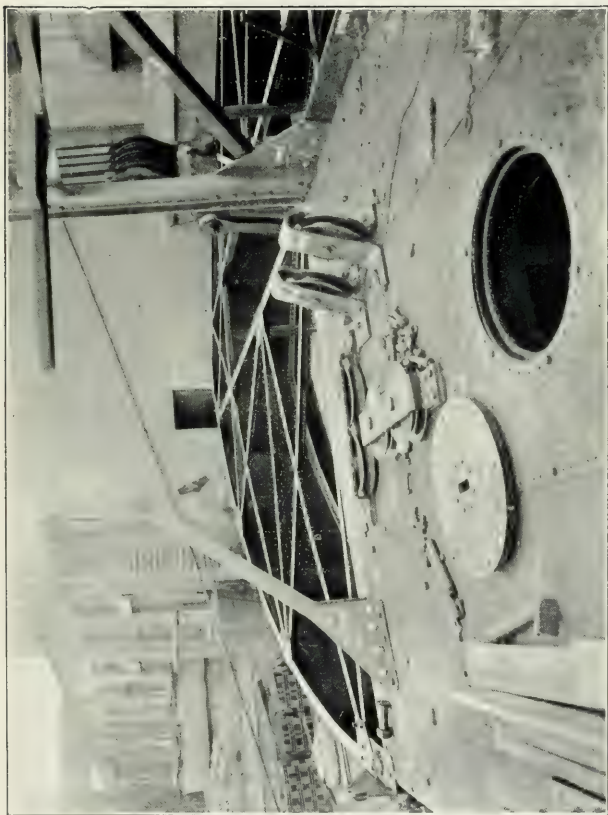
The only acid which will dissolve gold is *eau régale*. It consists roughly of one of nitric acid and three of hydrochloric acid.

* * * *

The melting point of gold is 2016° Fahrenheit and about 1100° centigrade.

* * * *

For rough calculations it can be assumed that a grain of gold is worth 2d., and a dwt. = 4s.



PORTION OF A STEEL PONTOON

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MERCURY, BLASTING, ETC. 55

A dwt. of gold in a cwt. of ore = 1 oz. of gold per ton.

One cubic inch of gold weighs '68 lbs.

One cubic foot of gold weighs 1,175 lbs.

Gold weighs about nineteen times as much as an equal volume of water.

The annual output of gold in the world is about 8,000,000 ounces.

British gold coin is eleven parts gold and one part copper. The annual loss to the British Government through the wear of gold coins in circulation is nearly £50,000.

* * * *

Dredging.—In reporting on or considering a dredging proposition, care must be taken not to underrate the expense of running. The 13-14 oz. a week which will keep an average size dredge going in New Zealand is of no use in West Africa where more like 25 oz. a week is required. The expense in connection with running dredges in countries like Patagonia and West Africa is great, and a big capital is involved. On this capital interest has to be paid, or is expected, so that unless about 30 oz. per week per dredge is regularly forthcoming the concern is not doing really well.

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The dredging season may roughly be assumed as :

All the year round in California and Southwards to the tropics.

Eight months in Colorado and 105-115 days in the Yukon, Alaska, and many parts of Siberia.

* * * *

In West Africa the ground holds average values of 7d. to 8d. per cubic yard, but it is patchy to a degree, and in many parts the values change largely from day to day. In California the average values are about 7½d. The average cost of running in West Africa is practically 6d. a cubic yard. In New Zealand a ground value of 3½d. will pay, but that is not a safe margin in most countries because, in the present stage of the industry's development, and while the chances of breakdown are so great, even the best conditions of working can hardly be called ideal.

* * * *

The biggest profits over a large area are believed to have been obtained near Oroville, California. On a strip of eighteen square miles bordering on the Feather River, between twenty and thirty dredges are working the property of twelve or fourteen



34 B WKS.

IMPROVED MULTITUBULAR BOILER, WITH CIRCULAR FIREBOX (TYPE "G"),
140 LBS. PRESSURE PER SQUARE INCH

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companies. The official figures are very hard to obtain, as they are all semi-private concerns, but they are all known to pay good dividends, one company in 1904 only spending about 32 % of the value of its bullion output. In California, however, it is probable that the conditions met with approach the ideal. The climate is delightful, being neither too hot nor too cold. All the dredging fields are situated directly upon railroads, and the dredges are in close proximity to the works of numerous electric power transmission companies. This enables them to secure horse power at rates varying from \$5 to \$8 per h.p. per month, and admits of the equipment of the entire dredging plant with electrical machinery.

* * *

The majority of the Californian dredges have wooden hulls because of the low cost and the minimum of risks attending the work in that locality. Screens and tables are used exclusively, as many experts consider the gold too fine to be saved by sluice boxes. Where the gold is coarse and nuggety, the latter are preferable, as, when the proper precautions are taken, they can catch such gold just as well as the more modern apparatus.

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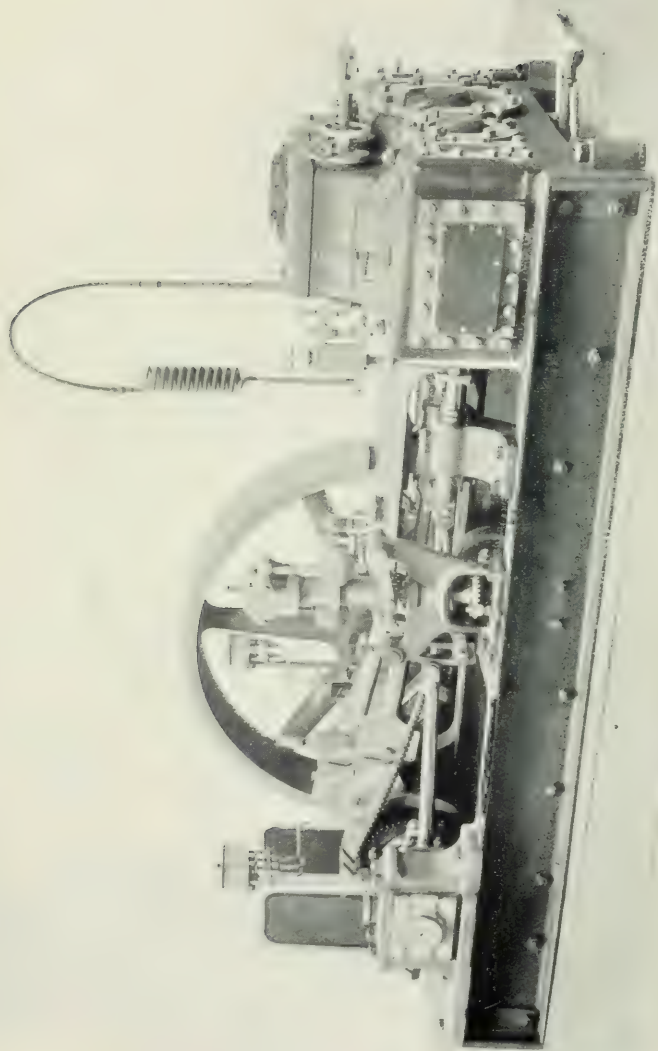
There is always the chance of nuggets of good size not being able to get through the perforations of a screen quickly enough to avoid being carried away by the *débris* to the elevator.

* * * *

The cost of fuel is always a great consideration. In California wood is about 16s. 6d. a cord, and electricity only about £1 4s. 6d. per h.p. This would make electricity about equal to wood at 8s. 3d. a cord, plus the capital outlay on the plant, etc. On the West African rivers, where the cost of plant and upkeep would work out much higher, good wood costs only about 6s. 6d. a cord, stacked alongside. It is always advisable to go very carefully into the question of motive power.

* * * *

Capacity.—The large amounts of material often quoted as being the capacity of a dredge are not reliable. Some say, for instance, that the amount treated by a dredge with five cubic feet buckets is 90,000 cubic yards per month, whereas constant observations have shown me that 30,000 cubic yards would be much nearer the mark. This figure is based upon the assumption that the



STEAM ENGINE SUITABLE FOR DRIVING DREDGER MACHINERY.

From a photograph kindly supplied by Messrs. Ruston, Proctor & Co., Ltd., Sheaf Iron Works, Lincoln.

dredge works twenty to twenty-one hours per day for six days per week.

* * * *

The average dredge only works for about 70 % to 75 % of its time, though two sluice dredges belonging to the Ashanti Rivers and Concessions, Ltd., have each run nearly 85 % of their full time for three or four months together. The degree of fullness of the buckets, moreover, is very variable, and there are times during the day when the winchman is "cleaning up the bottom," and for quite a time the buckets are full to only about a quarter of their capacity.

* * * *

Paddock Dredging.—In paddock dredging allowance must be made for the seepage through a dam consisting of tailings. For downhill work in a paddock or downstream work in a river, an abnormally high and long elevator must be used, otherwise tailings will drain back and encroach upon the dredge.

* * * *

Estimating.—For the estimation of auriferous gravel a pan may be assumed to hold from 15 to 30 lbs., say 20 lbs., as an average. About 160 pans run to the cubic yard, and

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a good day's work is to wash about 100 pans. The colours in the pan are divided into three classes. When great exactitude is required a fair sample of one cubic foot is taken, panned, and the results of the pannings weighed. By this means can be ascertained the weight per cubic foot *in situ*, the measurement of the gravel piled and loose, and the yield per cubic yard in the bank.

* * * *

Results.—That good results can be obtained from gravels which show low values is proved by the 1909 return from the five dredges owned by the Ashanti Rivers and Concessions, Ltd., in West Africa. The figures were :

| Ground heated | Oz. recovered | Hours worked | Firewood consumed |
|---------------|---------------|--------------|-------------------|
| 1,010,270 | 5,583 | 25,295 | 7,039 cords |

As the amount of ground really treated was probably, as explained elsewhere, very much less than the figures given, the profit from ground which is known to be consistently worth 2½d. per cubic yard should be very good.

Measurement of Running Water.—If the channel of the stream has a moderately



A CLOSE-TINED GRAB

From a photograph kindly supplied by Messrs. Priestman Bros.

even outline, measure its depth at regular intervals from shore to shore. Add all these depths together and divide the total by the number of soundings. An average depth is thus gained. Calculate, then, the area of the section. Measure the velocity by means of a float, and make the test about half-way between the banks and the centre. Multiply the area by the velocity and the product will be the flow. At the spot at which the test is made the banks should be parallel and the flow tranquil.

* * * *

The presence of tree stumps, bush, dead trees, lava, excessive pipeclay and boulders sometimes renders blasting imperative, but it should not be resorted to till cutting, dredging out and hauling astern have been tried. Firing blasts by electricity is largely advocated, but as even in well organized underground mining the operation requires care, for many failures and accidents occur from defective batteries and connections, and as dredging only involves occasional blasting, we will ignore this method.

* * * *

When the log, say, can be observed, the explosive can be applied in two ways, either

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by inserting the charge in a hole bored in the ground immediately underneath the stump or in a hole in the stump itself. The first method is preferable where it is desired to uproot the tree and where the ground is firm and hard. With a crowbar or borer make a hole very close under the stump in a downward slanting direction. The cartridges should be placed under the bottom of the trunk as near as possible to the centre. (See illustration A.) If it be difficult to bore the hole on account of the soil being dry, throw in a little water occasionally while working the bar. It is generally necessary to cut any surface roots around the stump if they project a few feet from the main trunk. When the result of the blast shows that the stump only has been split, and there is a cavity in the soil, an insufficient quantity of dynamite has been used. The second method should be adopted when it is necessary to break up the stump instead of removing it bodily from the ground. It is also preferable where the ground is light and loose. Use an auger of not less than $1\frac{1}{4}$ inches diameter, and, just above the ground bore into the tree at the strongest part of the wood. Make the hole as nearly



A CLOSE-TINED GRAB FILLED WITH
COMPACT SAND

From a photograph kindly supplied by Messrs. Priestman Bros.

horizontal as possible, extending it to the centre of the stump. (See illustration B.) If the bore-hole is sufficiently charged, the tree will either be blown out or so shattered that it can easily be removed; but if only one side has been blown out by the explosion, the hole has not been placed in the strongest part of the trunk. In dealing with trees it should be remembered that those with a list to one side are more easily blown out than those which are erect.

* * * *

In the case of very high banks it is more economical to blow out the bottom than to attempt to raise the superincumbent mass, and the charge should in this case be placed so that the line of least resistance is horizontal.

* * * *

Boulders of all sizes may be broken into pieces by dynamite even without the labour of preparing bore-holes in the stone. (When it is convenient to bore a hole into a boulder it is much better to do so, as the quantity of explosive required is thereby greatly reduced.) This can be done by placing a sufficient charge close underneath the stone in a hole made in the ground by a crowbar

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and firing it as in the case of a tree stump. (See illustration C.) A charge may also be pressed on the top of the boulder and covered with clay and stiff mud to serve as tamping and to retain the cartridges in position. (See illustration D.) Rocks cropping up through the soil can be reduced in a similar manner. Care should always be taken to place the cartridges in close contact with the boulder, as any interposing layer greatly weakens the effect of the explosion.

* * * *

The world's output of gold for each day of the year is about £250,000, one-third of which is produced by the mines of South Africa. The Transvaal is the biggest mining community in the world, the weekly output of gold being valued at from £500,000 to £600,000.

* * * *

Gold is sent to London in "bar" form, the weight of each bar varying from 400 to 1,000 ounces.

* * * *

Pure gold is worth £4 4s. 11½d. an ounce. Under the Act of 1844 the Bank of England is bound to buy all gold offered it at £3 17s. 9d. per *standard* ounce. It is possible to sell



A. PREPARING A BORE-HOLE

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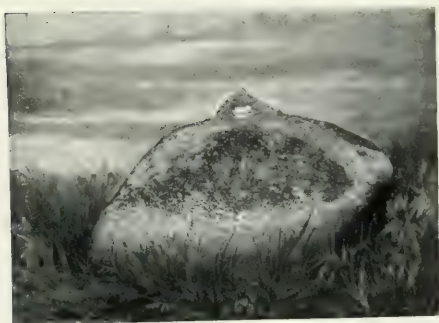
B. DRILLING A BORE-HOLE

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C. PREPARING A BORE-HOLE

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Co., Ltd.*



D. THE CHARGE IN POSITION

*Reproduced by permission of Messrs. Nobel's Explosives
Co., Ltd.*

gold to the Master of the Mint at £3 17s. 10½d. per ounce, but the metal is not paid for until twenty days have elapsed. As twenty days' interest at 3 per cent. equals the difference of 1½d. per ounce in the purchase price gold is not often disposed of in this way.

* * * *

The Bank of England can get £3 17s. 10d.-10½d. from a foreign country for bar gold, but as the foreigner can always get sovereigns if he wants them, and as that would necessitate the smelting down of more bar gold to replace the sovereigns, it is not safe for the Bank to force the price higher.

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